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Sprinkler Irrigation Management

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The Man Behind the Research

JOHN L. WIERSMA, a native South Dakotan and a South Dakota State College graduate, has been a staff member in the agricultural-engineering department since 1946. He has done both teaching and research, primarily in the area of irrigation.

"Irrigation," Wiersma says, "is not a 'get rich quick' solver of farming problems, but with proper management, which varies from farm to farm, there is a margin of profit. And, it gives a farmer an opportunity to expand and stabilize his enterprise without acquiring more land."

The agricultural engineer is currently a guest lecturer at the University of California at Davis, and will complete his Ph.D. Degree there next year.

Sprinkler irrigation management

By John L. Wiersma

Introduction

Successful sprinkler irrigation systems supply correct amounts of water to crops when water is needed and at a runoff preventing rate. Design and management are planned so this can be done with the least possible equipment and at the lowest possible pumping or delivery rate.

Irrigation farming is planned on the basis that water and available plant food are no longer limiting production factors. Solar energy for plant growth then becomes the most limiting factor. Most of South Dakota receives enough solar energy to use about 30 inches of water per growing season. Irrigation is planned to supply the part retained from natural rainfall. Conservation of natural rainfall is just as important to the irrigation farmer, therefore, as it is to the dryland operator.

Must Use Economical Rates

Water for a sprinkler system must be available throughout the growing season. Pumping costs increase in nearly a direct proportion to the pumping rate. A farmer must use the lowest rate that will supply the demand of design system. To balance the higher equipment costs of a sprinkler system, he must keep his operational cost economical.

Steps to Efficiency

Efficient management of a sprinkler system requires:

1. Using the root zone for a water reservoir.
2. Pumping the maximum number of hours per day.
3. Applying water as efficiently as is humanly possible.
4. Properly using a correctly designed system.
5. Growing crops having peak water needs at different times.
6. Using labor efficiently.
7. Using every means available to conserve natural rainfall.

Using soil root zone for a water reservoir

Soil will hold water depending on the soil's texture, depth, and amount of organic matter. Water removal rate depends on the plant's ability to remove it from the root zone. Good irrigation practices help by increasing the root zone depth. Most irrigated crops will have a root depth of at least 3 feet. Others, such as alfalfa, may go much deeper, depending on soil conditions. If the entire root zone is not wetted during each irrigation, however, the root zone becomes shallow and use of lower soil layers is not possible during later irrigations.

Capillary action will replenish water from below root zone depths and add to available soil moisture. Irrigation during the non-growing season can profitably replenish the entire soil horizon with water that can be used during the growing season.

Two Soils Used

In tests run on the Agricultural Engineering Research Farm, the utilization root zone stored moisture of two types of soils, Fordiville sandy loam and Volga silty clay were observed.

The Fordiville sandy loam was well drained with an average depth to gravel of 30 inches. It was capable of storing about 2 inches of water per foot or a total of 5 inches. Root penetration was slightly below this 30-inch depth.

The Volga silty clay loam had an average depth of 4 feet and water storage of 2½ inches per foot, or a total of 10 inches.

Three Crops Tested

Both soils were filled to field capacity in September of each year. Replicated plots of corn, oats, and soybeans were grown. As expected, natural rainfall affected the results. The experiments were run during years of below average annual rainfall and when Fall rains were about average. Fertility differences were also observed.

Any advantage shown by fall irrigation on the light soil was only on earlier maturing crops—wheat and oats. Corn and soybeans did not yield any higher, and corn actually yielded lower where fertility was lower. Even though foliage was heavier, ears failed to set. In all cases moisture was too low for the critical tasseling period. Foliage added by more moisture during prior growing periods had lowered food to a point where a greater stress was put on the plant at this period.

Little or no difference was noted on soybeans at any time on the light soil.

Water Increased Yields

Both winter wheat and oats had increased yields. Yields went up 5 bushels per acre for each acre inch of water applied. Test weights in all cases were from 2 to 4 pounds per bushel higher on the fall irrigated lands.

Deep leaching of soil nutrients

is possible on both of the soils used, and can become critical. Soils having shallow depths and low water holding capacity are more susceptible to leaching.

All crops on the fall irrigated heavier soil showed increased yields. The time and amount of natural rainfall caused this advantage to vary. This was true particularly on the later maturing corn and soybeans. These crops use more water than small grains and also have more critical stress periods.

Winter wheat and oats yields increased an average of 3 bushels per acre inch of irrigation water. Corn yields averaged about 4 bushels increase per acre-inch. Soil fertility must be adequate to obtain these results.

"Off-Season Irrigation" Pays

Using "off season" irrigation on lands other than those which the irrigation system was designed can also return extra profits. In a marginal rainfall area the extra money will often justify the original cost. Figure 1 is an example of an eighty-acre system with a 500 gallon per minute water supply located in the center. This requires about a quarter mile of main line and a half mile of lateral line to supply enough soil moisture to handle the critical period of most South Dakota crops. If this particular unit had an adjacent 80 acres of land on either side, purchase of an additional eighth mile of main line would off-season irrigate 160 acres. By use of the fall and early spring season, there would be adequate time to complete this irrigation.

If a choice can be made, the off season irrigation should be practiced on soils with higher water holding capacities and sustained irrigation on lighter soils.

Pumping hours per day

The irrigation period or the number of days allowed to apply water for one irrigation for a given design area is governed by the quantity of water pumped, the acres to be irrigated, the depth of water to be applied, and the hours of operation per day. Expressed algebraically the relationship is:

Number of Days = 453 x acres irrigated x depth applied in inches ÷ hours operation per day x quality of water (gpm).

Since there is a limit to the number of days in which an irrigation system can cover the irrigated area

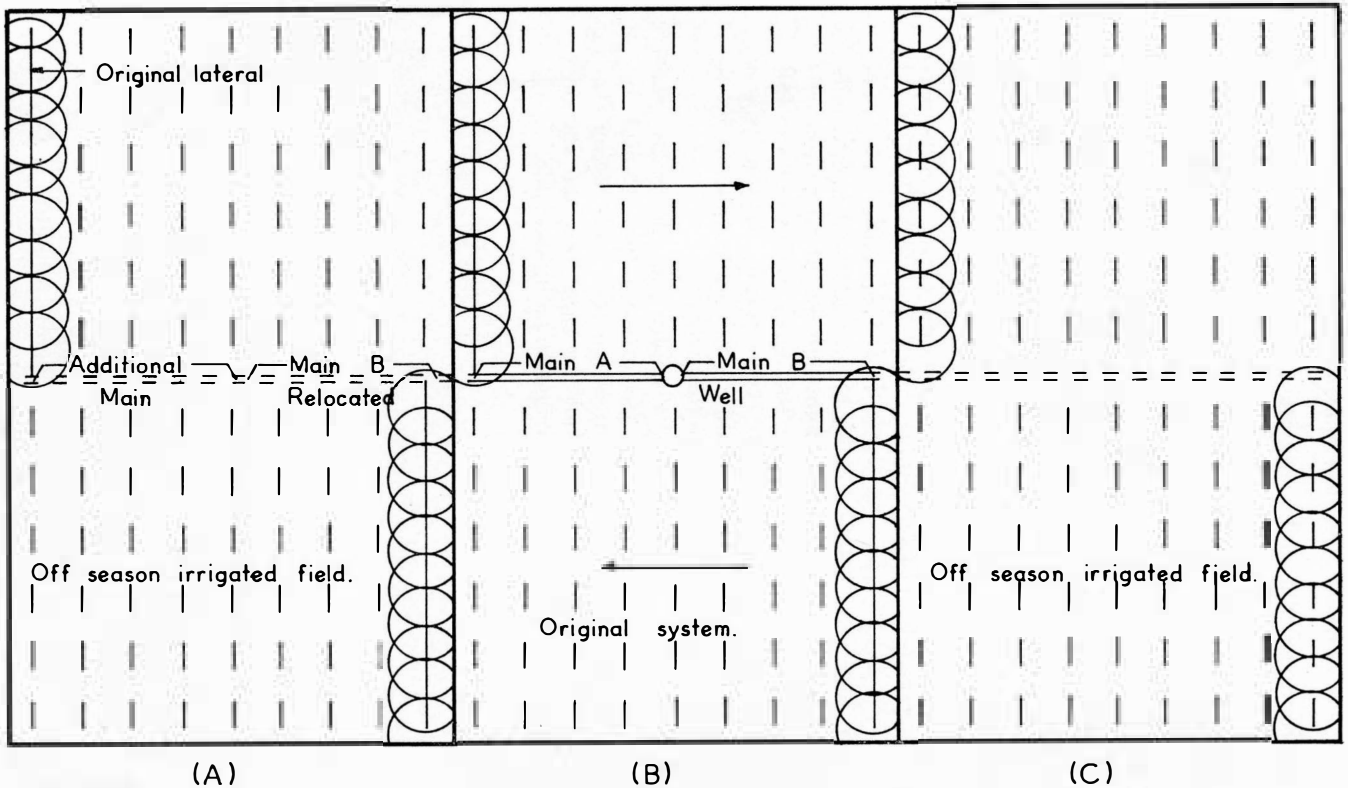


Figure 1
Example of possibility of off season irrigation on additional land. The system design is for field B. By purchase of 1/2 again as much main, two times the original design area may be irrigated during the off season. Selection of pipe diameter of main is based on entire area.

and still maintain enough soil moisture to prevent drought effects, the number of hours of operation a day has a tremendous effect on the pumping rate (gpm). Changing the hours of operation per day from 10 hours to 20 hours will decrease the pumping rate by 50%. The size of the pump, power unit, and pipe can all be decreased for a lower pumping rate.

Figuring Maximum Rate

Basically, the water application rate is the best way an irrigator can control his hourly operation per day. Maximum application rate is determined by the "no runoff" principle. Never apply water at a rate exceeding the soil's intake rate. Surface soil conditions may range from excellent surface conditions with good cover or surface mulch to a condition where no protection from surface crusting exists. Minimum application rate is regulated by amounts of water lost by evaporation and by mechanical operation of the equipment. In South Dakota a rate of less than 0.25 inches per hour is not considered efficient. (Any application rate between these two extremes may be used.) Choose one that provides for maximum operating time per day and adheres to the labor schedule of the irrigator.

Determining Hours of Operation

The amount of water to apply per irrigation depends on the water holding capacity of the irrigated area soil as well as the irrigation efficiency. The number of hours of operation per setting is equal to the total amount of water in inches divided by the rate of application in inches per hour. For instance, if the amount of soil moisture to be replaced is 3 inches and the irrigation efficiency is considered to be 75%, the amount of water to be applied would be 4 inches. If the application rate used was ½ inch per hour, the hours of operation per setting would be 4 inches divided by ½ inch per hour, or 8 hours.

It is nearly impossible to get three 8-hour sets (24 hours per day divided by 8 hours per set) per day because some time is need for moving pipe. Also, this would require moving pipe after dark, a situation to avoid except in emergencies.

Two 8-hour Sets

Therefore, this system would most likely be operated with two 8-hour sets per day, or a total operating time of 16 hours. This operation would require 225 gallons per minute if one acre were irrigated per set.

If the same system were operated so as to apply 0.35 inches per hour, the irrigation time per setting would be 11 hours (4 inches application divided by 0.35 inches per hour).

Two sets could then be made per day meaning you could cover the same area as with the higher rate. A flow rate of only 165 gpm would be necessary. Savings in equipment size can be made by applying the smaller rate.

By careful planning, and fitting the system into other farming op-

eations, it is possible to pump nearly around the clock. A system designed for continuous pumping will cost you more at first but the unit cost per inch of water applied will most likely be less.

Maintaining high water application Efficiency

Water application efficiency as used in sprinkler irrigation management is the ratio of the amount of water placed in the crop root zone and used by the crop to the total amount delivered to the field. This ratio is an important yardstick in management practices, because water costs the same whether you use it or lose it. If poor management practices and design result in below-average efficiency the area that can be irrigated will be proportionally less than an efficient system. The relationship is direct. A system which is 45% efficient can irrigate only half the area that a system which is 90% efficient.

Possible Losses

There are several factors involved in determining field application efficiency.

The following losses may occur:

1. Evaporation losses may result from the surface of flowing water or evaporation of water in the air by sprinkler nozzle spray.
2. Water may evaporate from the soil or leaf surfaces during irrigation.
3. Deep percolation causes loss below the root zone.
4. Runoff from the field.

Generally, the losses are a combination of these factors and may be difficult to separate.

Evaporation Losses

Evaporation from flowing water surfaces does not exist if the supply is from wells and water delivery is by a closed conduct. Only small losses are usually encountered from the surface of flowing water. Evaporation spray losses are dependent upon both climatic factors and operating conditions. The major climatic factors affecting the spray loss are relative humidity, temperature, and air movement or wind. Water losses are expected to increase with an increase in temperature and a decrease in relative humidity. The capacity of air to hold vapor increases under these conditions. Air movement or wind has an influence on the effectiveness of temperature and relative humidity. If the air moves through the sprinkler spray, greater amounts of water will be lost. If there is no air movement, seldom will more than 2% of the spray be lost by evaporation. Losses increase in a nearly direct proportion to increase in wind velocity. Under adverse conditions, temperature 100 degrees, relative humidity of 30%

and a wind of 20 miles per hour, spray water losses may be as much as 10%. This loss, however, is partially offset by the fact that the evaporation cools the air and decreases the transpiration rate of the plant during the irrigation.

Operating conditions which affect spray losses are nozzle diameter and pressure. In direct proportion, the smaller the nozzle and greater the pressure, the more water break-up. More surface area of sprayed water is exposed to the atmosphere and the evaporation rate is increased.

Sprinklers should be operated at factory recommended pressures. At extremely high pressures, water may be broken up to nearly a mist, and if a wind is present, drift will cause a water loss.

More Loss From Soil Or Leaves

Much more evaporation occurs from the soil or leaf surfaces than from spray during the irrigation. These losses vary with the same climatic conditions as spray losses. They are high during frequent light irrigations. A set amount of water is required to wet a given surface no matter what the total application may be. As the total amount of water applied decreases. the greater is the percentage of water lost from leaf and soil evaporation.

Table 1 is a summary of efficiencies obtained if only the evaporation losses were considered. This was on an alfalfa crop with a total application of 4.5 inches. No runoff occurred during the irrigation.

Less Evaporation At Night

Evaporation losses will generally be lower at night than during the day, but good management and design will require continuous system operation. Therefore, the irrigator will encounter different rates of loss during the irrigation operation. Compensation can be made for this by varying the application time of the night and day sets.

Table 1. Irrigation Efficiencies Obtained on Alfalfa Crop with Total Application at 4.5″ Considering Only Evaporation Losses

Wind mph	Relative humidity %	Application rate inch/hr.	Temperature °F	Sunshine hours %	Efficiency %
2.0	55	0.7	65	100	95
10.0	75	0.7	70	50	90
6.0	60	0.7	80	60	90
5.0	50	0.7	60	90	89
6.0	35	0.7	75	50	88
18.0	40	0.7	80	80	84
5.5	60	0.45	70	50	76
14.5	30	0.7	80	100	74
7.5	40	0.45	80	100	72
19.0	30	0.7	90	100	68
14.0	35	0.45	90	100	65

Losses due to deep percolation below the root zone occur with sprinkler irrigation as well as during surface irrigation. Uniformity of distribution will never be perfect with sprinklers. A detailed study on water distribution has been reported in South Dakota Technical Bulletin No. 16 entitled "Effect of Wind Variation on Water Distribution from Rotating Sprinklers". The following summary is given for this publication:

> Sprinkler systems have been designed in the past on the basis of a maximum wind velocity of 4 mph or less. In South Dakota an average wind velocity in excess of 10 mph is often experienced during the irrigation season. Unless original designs are modified poor irrigation efficiency is obtained.
>
> A number of tests were made from which the uniformity was calculated. From an analysis of these data the following conclusions were reached.
>
> 1. Tall risers are superior to short risers.
> 2. Angle of wind with respect to lateral line has little or no effect on the distribution pattern.
> 3. A definite breaking point in the uniformity point occurs between a 50-foot move between lines and a 60-foot move between lines.
> 4. High pressures are superior to low pressures.
> 5. Large quantities of water per nozzle result in better patterns than small quantities of water.
> 6. In winds of 8 mph or greater, a head with only the range nozzle is more efficient than a head with both a range nozzle and a spreader nozzle.
> 7. A sprinkler head with a large water capacity spaced 40 feet on the line is as good as heads with one-half of the water spaced 20 feet on the line.
>
> In this study, the uniformity was the only criterion considered. The conclusions may have to be modified when soil crusting, evaporation losses, labor schedules, rates of soil infiltration, size of water supply, type of equipment available, and the types of crops grown are considered in assessing the efficiency of sprinkler systems.

The irrigator's aim is to apply the same amount of water over the entire field or parts will be underirrigated and parts overirrigated. Good design is the key factor in obtaining the most uniform application.

The other possible water loss is called runoff loss. No loss should ever be encountered by this factor. **Application rates must never be more than the intake rate of the soil.** Intake rates of a given soil will vary with its cover and other cultural practices. The most adverse condition is used in design.

Proper use of a correctly designed system

Design and layout of a sprinkler system must be correct for successful irrigation. Next in importance, and closely related, is the proper operation of the system.

In many instances, failure to operate a system according to design has caused failure of the entire farming enterprise. In other cases, failure to recognize improper performance of various parts of the system have resulted in low efficiencies and high labor and pumping costs.

Pumping Equipment. Nearly every sprinkler system requires a prime mover and pump to furnish pressure for the system. This equipment is the heart of the entire operation. Pump failure during a critical period of crop growth can cause nearly complete crop failure for an entire season. And poor or inefficent operation can easily raise the pumping costs. Thus a pump and power unit with high operating efficiencies and trouble free performance should be part of design.

Turbine vs. Centrifugal Pumps

From the practical point-of-view turbine pumps are more trouble free than centrifugal pumps. This is true not only because of pump characteristics, but also because of operating conditions. The suction side of a centrifugal pump is often the "troublesome" side and a "power robber". All air must be removed from the suction line for efficient operation. Any air leak or pocket operation will decrease the head and quantity of water delivered without a decrease in power requirement and often causes complete pump failure.

Removing Air Pockets

To remove air pockets, the highest point in the suction line should be at the pump and the suction line laid on a slight slope away from the pump. Avoid any high points in the line. If a foot valve for priming or a strainer for stopping debris must be used, sufficient capacity must be available to keep the friction loss within the valve or strainer equal to less than one foot of head. The suction line must be submerged deep enough in the water to avoid a vortex. This requires a depth equal to 4 to 5 times the diameter of the suction line.

On all centrifugal pumps, the relationship is that the greater the suction lift the more inefficient the pump. This lift includes not only the static head, but also the friction and velocity head. Since there are no manual adjustments on centrifugal pumps nearly every cause of trouble can be traced to the suction side.

Adjusting Turbine Pumps

Turbine pumps have no suction lift because the impellors are installed below water level. Turbine pumps however, have a manual adjustment for clearance between the bowl and the impellor. This adjustment affects the efficiency

of operation. Pump manufacturers have detailed and clear instructions for making this adjustment but often they are overlooked by the operator.

An incorrect adjustment of as little as 1/32 of an inch can often lower the efficiency as much as 10%. An actual test example demonstrates the importance of proper impellor clearance. A particular pump was 70% efficient under proper adjustment. The quantity of water pumped was 1 cubic foot per second (450 gallons per minute) at a pressure of 60 pounds for 1000 hours (normal average number of operating hours per year). The electric power unit was using energy costing 2 cents per KWH. Improper adjustment lowered the efficiency to 60%. On this installation the added power cost per year was $70.00.

Units Require Care

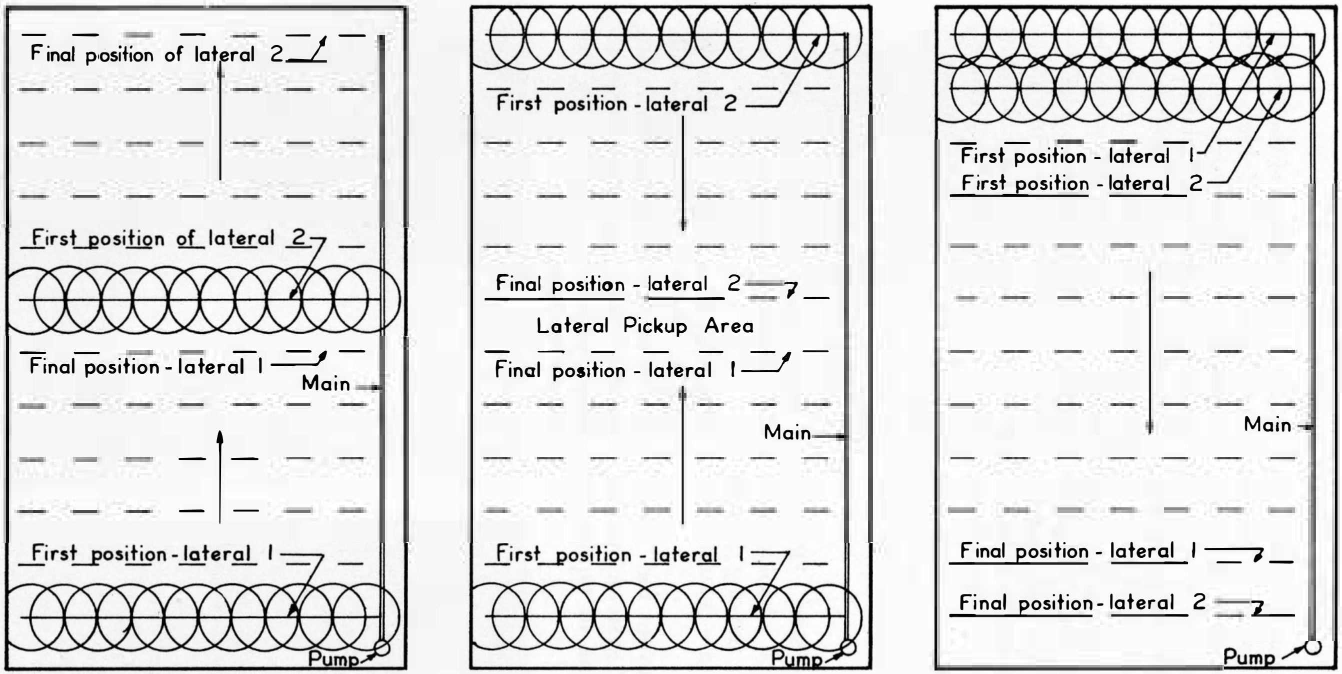
Pumping unit engines require the same care as those on tractors and automobiles. Poor care and maintenance shoot up power costs. Electric motors require less care and little can be done to affect operation under normal maintenance.

Sprinkler Heads. Sprinkler heads are delicate and need special care. A common cause of failure is uneven rate of rotation which affects the uniformity of water application. This uneven rate of rotation can be caused by normal wear or careless handling. A lateral line which frequently tips and forces the sprinkler heads into the soil for example will greatly shorten the life of a sprinkler head. Hauling laterals on trailers is a good way for heads to become bumped and bent. In any case, heads which do not rotate evenly should be quickly repaired or replaced.

Lateral Lines. Hand move laterals are impractical in tall growing crops, such as corn. On short crops, such as pasture, time can seldom be saved by using a wheel move or tow-line instead of a conventional hand move. In planning a layout, time, effort, and pumping costs can be saved by good planning. For example, figure 2 shows two lateral lines in operation simultaneously. They are also to be used on another field. If both were started on the edge of the field and worked toward the center rather than one at the center and the other at the edge, the two lines could be picked up with one trip across the field. However, if the irrigation is to be continuous on one field, the layout should be as shown in "A" because line number one can then continue all the way across the field on the second irrigation without being picked up. Line 2 can then be picked up when it reaches the far end and moved to the position that line 1 started. In no case should the layout as shown in "C" be used.

"B" Layout Most Economical

Under layout "C" moving would be difficult and time consuming, and pumping costs more because the entire rate of flow would at one time be pumped to the far end of the field. In "A" and "B", the



(A) Desirable layout if this is the only field on which system is used.

(B) Desirable layout if system is to be moved to another field between irrigations.

(C) Undesirable layout under any condition.

Figure 2 Layout variations which affect pumping and labor.

entire rate is pumped only one-half way at any one time. Layout "B" is most economical in pumping costs. By analysis of areas to be irrigated in this way big savings can be made.

Fields in which tractor tow lines are used should be planted to strips of low growing crops such as grain sorghum, beans, or alfalfa. Figure 3 demonstrates these strips. About 70% of normal irrigated crop production have been gained from these strips when planted to such crops.

Laying Out "Boom" Types

The "boom" type sprinkler also requires strips for moving (figure 4). These strips are planted according to the design of the system. The "boom" type sprinkler, which is usually also a pipe carrier, should be started at the most distant point from the main line and then moved toward the main. "Booms" are more easily moved on dry areas and by laying out the lateral line pipe before irrigation when maximum load is on the "boom" carrier. If more than one "boom" sprinkler is used on a single pump, the same principle applies as on the hand move as far as dividing the water so the entire flow rate is not carried to the distant end of the field at one time.

Main Line. For ease in operation, the more permanent a main

Figure 3. Field layout for "boom" sprinkler or "tow" system. Spacing depends upon type of equipment used.

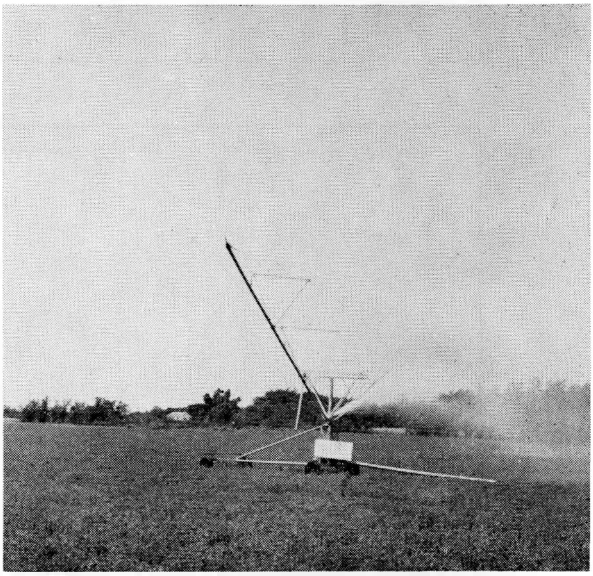
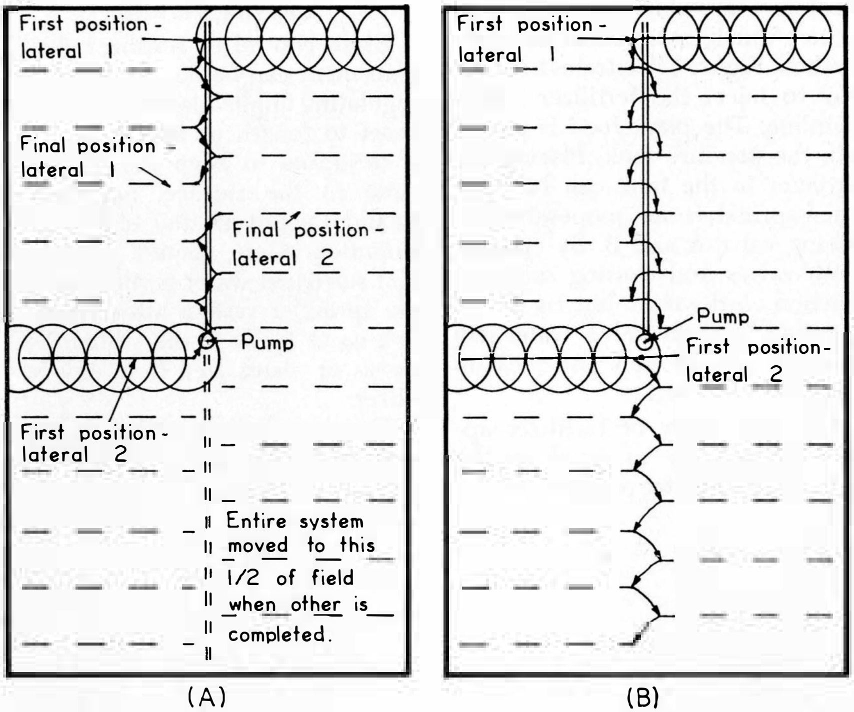


Figure 4. Boom type sprinkler on alfalfa. "Booms are more easily moved on dry areas and by laying out the lateral line before irrigation when maximum load is on the "boom" carrier.



(A) Mainline must be broken every time lateral 2 is moved. Note excessive moving of laterals for second half of field and second irrigation. This is an undesirable method of operation.

(B) As mainline is removed from position of lateral 1 it is added to main at position of lateral 2. Note no crossing or breaking of mainline. Lateral 1 moves across the entire field and 2 is moved to original position of 1 for next irrig.

Figure 5
Layout variations for TowLine systems.

can be, the better. On low growing crops, moving time can be lessened by having main line valves for lateral take-offs instead of tow line systems. Generally, main lines are larger and heavier pipe than lateral lines and do not drain as easily.

Avoid having to break into a main line on every lateral set, When this condition is necessary on systems that are not hand move, a slip joint section such as is shown in figure 6 can be used. However, breaking into a line is a time consuming and provoking job that requires a shut down of the entire system.

Fertilizer Application. The application of soluble fertilizers

through a sprinkler system proves to be a quick, economical, effective method. Figure 7 illustrates a simple way to inject the fertilizer into a mainline. The plant food is placed into the pressure tank. Placing the fertilizer in the tank can be done when sprinklers are in operation by closing valve A and B. By opening these valves and causing some restriction on the main line by use of a gate or butterfly valve, water will flow through the tank and pick up dissolved fertilizer.

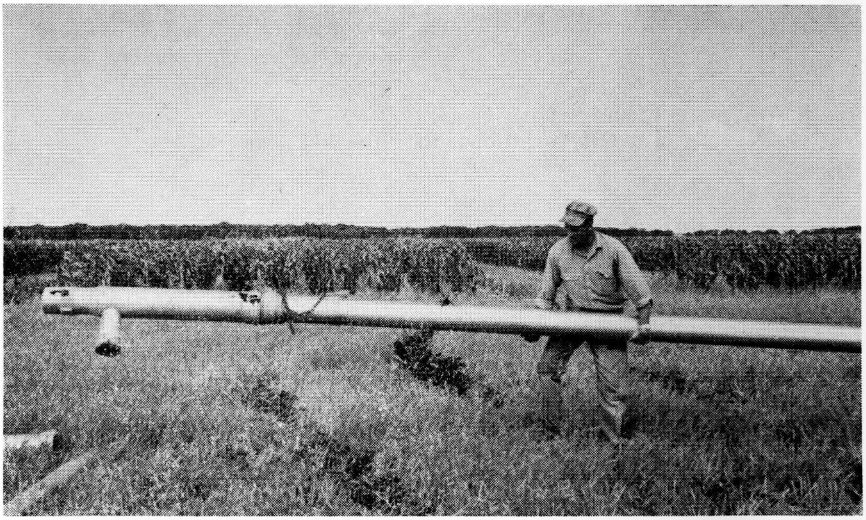
The uniformity of fertilizer application is only as good as the uniformity of water application.

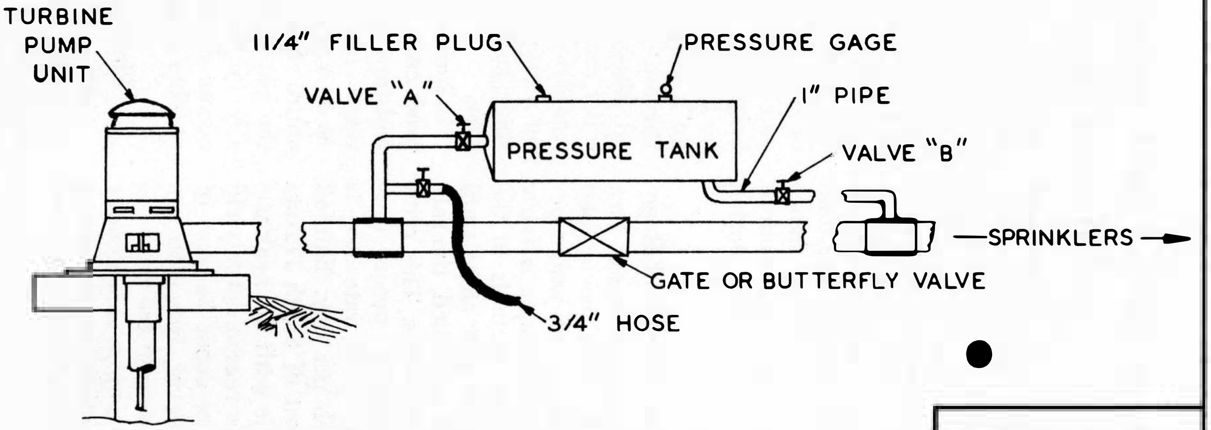
Applying Fertilizer

Close control of fertilizer depth placement can be accomplished by regulating application time with respect to length of irrigation. If it is desirable to keep the fertilizer close to the surface, application should be toward the end of the irrigation. Care should be taken that sufficient water is run through the sprinkler system after application so as to wash the system and leaves of plants free from any fertilizer.

The three-fourths inch hose connection can be used to rinse off the apparatus,

Figure 6. Slip joint section can be used where a main line must be broken during a later move. Good layouts and operations keep the use of this practice to a minimum.





APPLYING FERTILIZER THROUGH SPRINKLER SYSTEMS

Figure 7

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Using crops having peak water requirements at different times

Peak use periods of various crops vary during the growing season. Knowing when these peaks occur is an important factor in sprinkler irrigation management. This needs to be known so that a maximum number of acres can be irrigated by a given water supply. The total seasonal water use and importance of water during peak use periods will vary from crop to crop during the growing season.

Use More Water After Boot Stage

Small grains such as wheat, flax, oats, and barley will use a total of about 15 inches of water per season. The use of water is fairly constant until the grain is in the boot stage. From that stage until the grain heads are filled, the rate of water use increases. This critical period generally occurs during June. The peak rate use is about 0.20 inch per day. Rainfall patterns in most of South Dakota usually coincide with the peak use period. For this reason, large yield increases do not occur because of irrigation. However, irrigation can be profitable because the peak use period of these crops is considerably different from other irrigated crops and the system may as well be used as stand idle.

Irrigating Alfalfa

Alfalfa is a heavy seasonal user of water because of its long growing season. Alfalfa will use about 24 inches per season but does not have an extreme peak use period. The higher the temperature the greater its use rate, with a maximum of about 0.25 inch per day. Do not apply water during the week prior to harvest. This aids harvesting operations. Also, if the plant is dormant for a period of time immediately after harvest, and then given a good cover of irrigation water, yields will not be lowered. Instead there will only be a delay in regrowth and next harvest. This practice can be used advantageously during peak use of other crops. By delaying alfalfa irrigation farmers can concentrate on a crop with a critical moisture stage, such as corn during tasseling time.

In some areas alfalfa seed is also produced under irrigation. High moisture levels after the blossom stage are undesirable for the seed. A good practice is to fill the entire root zone immediately after the last hay crop is removed, usually in June. This irrigation then occurs during a low peak period of other crops.

Planning Corn Irrigation

Corn is not an exceptionally high seasonal water user. It requires about 18 inches per year, but has a period when moisture is critical (from tasseling to silking). Lack of water at this time can cause permanent injury. During this peak use period as much as 0.30 inch per day will be used. This fact

makes corn a profitable crop to irrigate because large yield increases are possible. Natural rainfall is often deficient during this peak use period. An irrigation system should be designed and used so that this peak use amount can be supplied to the corn acreage if rain does not occur. After the milk stage, the use rate decreases and a nominal amount of moisture stress for a short period of time will not materially affect the crop.

Sorghum Much Like Corn

Grain sorghum has nearly the same moisture use characteristics as corn except that its seasonal use and peak use rate is less. Sorghum has less foliage than corn and is a more efficient user of water. The desirable feature of irrigating grain sorghum, aside from the fact that it is shorter than corn for hand move systems, is that its critical moisture use period – the boot stage—is not as high as corn. For this reason, a longer moisture stress period will not decrease the yield as much as corn. On experiments, nearly a direct ratio of 6.5 bushels of grain sorghum were harvested per acre inch of water used whether a moisture stress period occurred or not. Corn differs in that it is possible to get no yield if water is not available during the tasseling stage.

Water On Potatoes

Potatoes use about 15 inches of water per growing season and have a low peak use rate. It is important to have the entire root zone moist during the early growing season to encourage deep root growth. But after the blossom stage the first foot of root zone is the control zone for production of high quality tubers. Unless this practice is followed, low quality will result, even though as many bushels of potatoes may be harvested. Potato irrigation is a difficult job because many light irrigations must be given to keep the top foot of the root zone moist. Extreme care must be taken in selecting nozzle size and pressure because unless good droplet breakup is obtained, soil washes off the tubers and a crust forms, usually resulting in sun scald tubers.

Rates For Sugar Beets

Sugar beets are high seasonal water users with use rates increasing until about August 1 and remaining high until frost. Because of the long season, peak use rates are low and no highly critical period exists. Beets need irrigation long after corn. One light irrigation immediately after seeding to insure a stand is usually profitable.

Efficient utilization of labor

Labor requirement is one of the most important considerations in sprinkler design and operation, but unfortunately, is frequently overlooked. Labor needed will vary with the efficiency of the operation, soil type, topography, kind of crop irrigated, pipe length and diameter type of coupler used, system design or layout, depth of water applied per irrigation, length of time per setting, and distance the lateral is moved per setting.

Avoiding Wet Moving Conditions

Except for tall crops, such as corn in later stages, moving a sprinkler line is not particularly difficult, but is objectionable to many people because of wet, muddy conditions.

Wet vegetation and water in the lateral line are particularly irritating. This can be corrected easily by shutting off the system a short time before the pipe is moved. Also "self drain" valves can be installed in the lateral line. The valves can be bought commerically at small cost. This "pre-shutting off" of a system can be done mechanically with time clocks. If this is done, there is time for most of the surface water to evaporate and give the pipe time to drain. Many times only a half hour is needed and moving conditions are improved so much that the irrigator can actually save time in the long run.

Time Schedule Important

Most irrigators do not hire help exclusively for the irrigation system. This work can generally be integrated with other farm work. It is important, however, to set a time schedule so that pipe moving can be done easily. Most successful irrigators move lateral when it does not interrupt normal field operations—usually early morning, noon, or evening. A "two moves a day" schedule—morning and evening—is usually the most efficient and practical. This is because a noon move necessitates another move at midnight, which is highly impractical.

Low Rate Systems More Moveable

A labor survey noted that the lower application rate system—around 0.35 inches per hour—required less time to move per acre irrigated than the higher application rate systems. This was for hand move systems.

This is because the lower application rate systems can utilize smaller diameter pipe and, consequently, are easier to move. Hand move systems should not have lateral lines greater than 4 inches in diameter for efficient labor use. A center-located riser on pipe 30 feet long with a maximum of 4" diameter had the most efficient labor utilization coefficient of all hand move systems encountered. This was for a one man operation. If two men are used, an end riser is desirable, but few systems can justify two men moving one piece of pipe.

Figuring Labor Needs

Naturally, a direct relationship exists between the number of irrigations performed per season and the amount of labor required. An average of one man hour per irrigation per acre is required for average conditions on hand move systems. If an irrigator does not completely fill the root zone each time, more irrigations per season will be required and a proportionately greater amount of labor. For instance, if the root zone had a capacity to hold 4 inches of water and only 2 were applied, twice as many irrigations would be required and twice as many man hours of labor to move pipe.

Equipment is being designed to cover greater areas per irrigation and will give proportionate labor savings. If a lateral can be moved 80 rather than 60 feet, ¼ less moves will be required to cover a given area, but only about ⅙ more time is required to move a line 80 rather than 60 feet.

Saving Labor

Wheel moves, tow skid lines, and other types of mechanical moves are being designed to counteract the present labor problem. On short growing crops, such as pasture and alfalfa, a survey has shown that on most systems no time has been saved by these installations, but the objections to the wet working conditions have decreased.

Conservation of natural rainfall

Irrigation is not a universal cure for moisture requirements for all crops.

Rainfall can be made to be nearly 100% efficient if conservation practices are installed on an irrigated area. Moisture retained from rainfall does not need to be applied by irrigation.

Above normal or abundant rainfall on a properly managed irrigation farm can be utilized more efficiently than on a non-irrigated farm. Planting rates and fertility levels on irrigated farms are maintained at a higher level to effectively utilize water. If abundant rainfall is experienced, the irrigation farmer has the proper conditions to utilize this natural resource.

Successful irrigation is predicated upon the premises that sunshine or solar energy is the only limit to production.